Overeducation and skill-biased technical change*

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Abstract

There is evidence that rising overeducation has coincided with rapid skill-biased technical change (SBTC). This paper shows that a SBTC can cause a rise in overeducation as firms looking for educated workers become more selective and turn down the less skilled candidates. This result, while consistent with the evidence, is in contrast with the implications of recent search and matching models of the labor market. Here we present a model of a segmented labor market, with imperfect correlation between the individual ability and the observed education of workers, and a fixed cost of setting up a job. A numerical illustration for the U.S. in the period 1970-90 demonstrates that overeducation rises and that it can in turn be significant for the response of unemployment rates and wage inequality to a SBTC.

Keywords: overeducation, skill-biased technical change, wage premium, unemployment

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1 Introduction

A skill-biased change in technology (SBTC) is commonly regarded as a primary explanation for the widening dispersion of wages.\(^1\) Yet only a few papers in the standard search matching literature have also studied its implications for overeducation alongside other labor market variables.\(^2\) These works suggest that a SBTC should cause overeducation to decrease. The idea is that educated/skilled workers become more likely to reject jobs for which they are overqualified and wait until finding a better one.

There is however growing evidence of increases in overeducation since 1970 in the U.S.\(^3\) Slonimczyk (2013) (Table 5) finds that the proportion of overeducated workers had doubled between 1973 and 2002, with most of the change having taken place by the early 1990’s. Pryor and Schaffer (1997) (Table 1), Vaisey (2006) (Table 2), and Layne (2010)(Table 1) document that since since 1971 university graduates have increasingly been taking jobs in which the average educational level is much lower.\(^4\) These increases in overeducation have coincided with a period of rapid SBTC and increasing wage inequality.

This paper offers a possible explanation for a rise in overeducation as a consequence of a SBTC. It is based on a model characterised by within-group unobserved skill heterogeneity. Following a SBTC, firms searching for educated workers become more selective in their hiring policies, rejecting candidates who, in spite of their credentials, turn out to be poorly skilled. These low ability educated workers will then seek employment in jobs that do not require a qualification and become overeducated. This response of overeducation proves in turn significant for understanding changes in unemployment rates across education groups and wage inequality.

A key premise behind this story is that productive skills and education are imperfectly correlated, with overeducation occurring among those educated workers with lower productive ability. There is empirical evidence that supports this characterization of overeducated workers as those lacking skills of graduates. Chevalier and Lindley (2009) provide compelling evidence that overeducated graduate workers tend to lack both non-academic (like entrepreneurial, management and leadership) skills and unobservable characteristics (such as motivation and punctuality) often considered crucial to succeed in the labor market.\(^5\) Pryor and Schaffer (1997) study issues of functional literacy in overeducated workers, and Leuven and Oosterbeek (2011) (section 4.2) survey a number of papers that consider their distinctive characteristics across different ability measures. Beyond the issue of overeducation, the heterogeneity of abilities is a theme of research studying the influence on labor

\(^1\)The literature is vast. See Autor, Katz, and Kearney (2008) for an overview of the evidence.

\(^2\)Acemoglu (1999), Albrecht and Vroman (2002) and Dolado, Jansen, and Jimeno (2009).

\(^3\)A worker is defined as overeducated when she is employed in an occupation whose required qualifications are lower than her own educational level.

\(^4\)See also Wolff (2000) (Table 2.2) for additional evidence.

\(^5\)See also Chevalier (2003).
market outcomes of individual characteristics and behavioral traits other than schooling or work experience.\cite{note6}

Our view of SBTC is consistent with the technology-skill complementarity hypothesis studied in, for example, Krusell, Ohanian, Ríos-Rull, and Violante (2000) from a macro perspective, and for which Autor, Levy, and Murnane (2003) provide microevidence. Technical change, consisting of the adoption of computer-based technologies, is strongly complementary with tasks that require nonroutine analytic skills and substitutable with tasks that only require routine skills. This type of technological change causes a widening of the productivity gap between those graduate workers who possess nonroutine skills and those who do not. Following Autor, Levy, and Murnane (2003), some authors have identified in this context the phenomenon of 'job polarization' whereby middling or routine jobs are on the wane.\cite{note7} In our formal analysis, a SBTC will cause a form of job polarization since qualified jobs formerly held by less skilled educated individuals disappear; overeducation is one side of this process as it describes the migration of those workers towards unqualified jobs.\cite{note8}

Our formal approach is based on a simple matching-search model of a labor market that, similarly to Cuadras-Morató and Mateos-Planas (2006), is segmented into two types of jobs defined by their educational requirements. Educated workers are differentiated by the skill (or ability) at which they perform qualified jobs. Whereas a non-educated worker can only participate in the non-educated segment, an educated worker has to decide which of the two segments to target depending on the employment and wage prospects associated with the two alternatives. Thus an educated worker may turn to the non-educated segment and become overeducated when her chances of employment in the educated segment are small. The existence of a positive fixed start-up cost to creating a job is critical for overeducation to arise, since it is the reason why firms in the educated segments may not hire low-skill workers.

We demonstrate the results in a calibrated version of the model. The main exercise of the paper consists of considering the effect of a SBTC that widens the productivity advantage of high-skilled workers. This leads to a situation where firms looking for educated workers do not find it profitable to hire low-productivity individuals. These workers will, consequently, turn to seek employment in the segment of the market that does not require qualified workers, i.e. they will become overeducated. These overeducated workers are subject to the high-unemployment conditions in the non-educated segment, thus raising the average unemployment rate of educated workers. The rise in overeducation also contributes to cause a higher unemployment rate for non-educated workers and a wider wage dispersion both across and within education groups. These implications are all consistent with the observed

\footnote{See Bowles, Gintis, and Osborne (2001) for a review.}
\footnote{Slonimczyk (2013) also invokes the idea of polarization to suggest an empirical connection from SBTC to overeducation.}
changes between 1970 and 1990 in the U.S. labor market. Alternative explanations for overeducation (e.g., a rise in the share of workers with a college degree) are also considered and analyzed within the setup of the model.

Acemoglu (1999), Albrecht and Vroman (2002) and Dolado, Jansen, and Jimeno (2009) study random search-matching models with heterogeneous firms and workers where overeducation happens in the form of skill mismatches. Overeducated workers in these papers are highly skilled individuals who are are happy to take on the first offer they receive and may therefore end up in a low qualified job.\(^9\) The general prediction of these models is that a SBTC, by increasing the premium for the worker to doing a qualified job, must reduce the level of overeducation, which goes against the evidence discussed above.\(^10\) The present model is instead one of directed search where overeducated workers are low ability individuals who are turned down when applying for qualified vacancies.\(^11\) They are in this sense inadequate, quite a different view from that of the previous papers. As pointed out earlier, recent empirical studies lend support to this characterization.\(^12\) The contribution of this paper to the literature is to show that this view can rationalize the observed rise in overeducation as a response to a SBTC, and that it is also relevant for unemployment and inequality in the labor market.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 characterizes the equilibrium. Section 4 describes the calibration and the numerical exercise. Section 5 concludes.

2 Model

There are two types of agents in the model, workers and firms. Workers are heterogeneous along two dimensions: skill (indexed by \(j\)) and education (indexed by \(i\)). A worker can be skilled \((j = s)\) or non-skilled \((j = ns)\), and educated \((i = e)\) or non-educated \((i = ne)\). A firm consists of a job vacancy with a specific education requirement. A job type is defined accordingly, educated or non-educated \(i \in \{e, ne\}\). Only educated workers can perform an educated job. This implies that the labor market is segmented by education requirements,\(^9\) Formally, overeducation arises in situations in which educated workers accept job offers from both educated and non educated firms (pooling equilibrium), as opposed to situations where educated workers do not take low qualification jobs and wait for better opportunities (separating equilibrium). Dolado, Jansen, and Jimeno (2009) extend that model with on the job search where overeducation is a more transitory situation.\(^10\)

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\(^10\)Chassamboulli (2011) presents a similar model although does not analyze the issue of SBTC and focuses instead on the cyclical behaviour of skill mismatches.

\(^11\)In the literature there are directed search models with heterogeneous agents and wage posting (our model has wage bargaining instead), but they do not deal with the issue of overeducation. In Shi (2002) wage offers are made conditional on workers’ types, while in Peters (2010), Eeckhout and Kircher (2010), and Lang, Manove, and Dickens (2005) wage offers cannot be conditioned on them.

\(^12\)Chevalier and Lindley (2009), Chevalier (2003), Pryor and Schaffer (1997) and papers reviewed in Leuven and Oosterbeek (2011).
with a matching process taking place in each segment separately.\textsuperscript{13}

\textbf{Workers.} Let \( \phi \in \{0, 1\} \) represent the decision of an educated non-skilled worker whether to participate (value 0) or not in the educated segment.\textsuperscript{14} Overeducation happens when \( \phi = 1 \). Let \( \mu(j, i) \) denote the exogenous fraction of workers with skill level \( j \in \{s, ns\} \) and education \( i \in \{e, ne\} \). We will assume the that the majority of educated workers are skilled (\( \mu(s, e) > \mu(ns, e) \)) and that the majority of non-educated workers are non-skilled (\( \mu(s, ne) < \mu(ns, ne) \)). Therefore the skill composition of the labor force in each segment, \( p_{ji} \), is determined as

\[
\begin{align*}
{p_{se}} & = \frac{\mu(s, e)}{\mu(s, e) + (1-\phi)\mu(ns, e)}, & {p_{ne}} & = \frac{\mu(s, ne) + \phi\mu(ns, e)}{\mu(s, ne) + \mu(ns, ne) + \phi\mu(ns, e)} \\
\end{align*}
\] (1)

The probability that a worker searching in segment \( i \) makes contact with a suitable firm is \( \nu_i \). The value to a worker with skill \( j \) seeking employment in segment \( i \) is denoted by \( U(j, i) \). After contacting a firm, the skill of the worker \( j \) is revealed and the worker must agree with the firm whether to create the job or continue searching. The decision of the firm about hiring the worker is denoted by the indicator \( \pi_{jji} \in \{0, 1\} \), with value 1 if the decision is positive. If the job is created, the wage to the worker is \( w(j, i) \) and the value of the match is \( W(j, i) \). The job is terminated exogenously with a Poisson probability \( \lambda \). If this happens, the agent becomes unemployed and searches for a new job. There is a flow value to the unemployed worker that depends on the wage \( b(w(j, i)) = b_0 + b_1 w(j, i) \). Also, a worker leaves the labor force and is replaced with a constant probability \( \rho \). With the future discounted at the constant rate \( r \), the worker maximizes the present value of wages plus unemployment compensation. The Bellman equation for \( W(j, i) \) is

\[
(r + \rho)W(j, i) = w(j, i) + \lambda(U(j, i) - W(j, i)).
\] (2)

The value of unemployment for a worker is

\[
(r + \rho)U(j, i) = b_0 + b_1 w(j, i) + \nu_i \pi_{jji} \max\{W(j, i) - U(j, i), 0\}.
\] (3)

As for the key career (or segment) choice of an educated unskilled worker

\[
\phi = \begin{cases} 
0 & \text{if } U(ns, e) - U(ns, ne) > 0 \\
1 & \text{otherwise}
\end{cases}
\] (4)

\textbf{Firms.} A firm posts a job vacancy that specifies an education requirement (or market segment), \( i \). The value of the vacancy is \( V(i) \). The firm contacts a suitable job seeker with probability \( \xi_i \). The fraction of workers with skill \( j \) within the pool of unemployed workers participating in the market segment \( i \) is denoted \( z_{jji} \). The flow recruiting cost of

\textsuperscript{13}A similar assumption is made in Mortensen and Pissarides (1999).

\textsuperscript{14}We will consider only equilibria in which the educated and skilled will always target vacancies of the educated type, so we omit this choice to save notation.
posting a vacancy is \( c_R \). Upon contact, and after the worker’s skill is revealed, the firm and the worker agree on whether to create the job. As before, \( \pi_{ji} \in \{0,1\} \) denotes the hiring decision. When the job is created, the firm has to pay a fixed cost of \( c_k \) units. The firm starts operating and earns the flow \( \eta_j - w(j,i) \), where \( \eta_j \) denotes the productivity of a worker with skill \( j \). The value of the job match for the firm is \( J(j,i) \). When the job is terminated, the firm will seek to open a new vacancy type \( i \) of the highest value. The firm also discounts future values at the constant interest rate \( r \). Formally, the Bellman equation for \( J(j,i) \) is

\[
 rJ(j,i) = \eta_j - w(j,i) + (\lambda + \rho) \left[ \max_{i' \in \{e,ne\}} V(i') - J(j,i) \right],
\]

and for \( V(i) \),

\[
 rV(i) = -c_R + \xi_i \sum_{j=s,ns} z_{ji} \pi_{ji} [J(j,i) - V(i) - c_k]
\]

\[
 \pi_{ji} = \begin{cases} 
 0 & \text{if } J(j,i) - V(i) - c_k \leq 0 \\
 1 & \text{if } J(j,i) - V(i) - c_k > 0 
\end{cases}
\]

Matching. The matching technology is specified as \( m(v,u) = v^{1-\theta} u^\theta \). This function gives the number of matches per period in segment \( i \), \( m(v_i,u_i) \), where \( v_i \) is the mass of vacancies and \( u_i \) is the number of unemployed workers in this segment. Therefore the probabilities of contact for firms and workers, \( \xi_i = m(v_i,u_i)/v_i \) and \( \nu_i = m(v_i,u_i)/u_i \), are

\[
 \xi_i = \xi(v_i/u_i) \equiv \left( \frac{v_i}{u_i} \right)^{-\theta}, \quad \nu_i = \nu(v_i/u_i) \equiv \left( \frac{v_i}{u_i} \right)^{1-\theta}
\]

Equilibrium. The firm and the worker bargain at each instant over the surplus of the match to determine the wage. Let \( \beta \) represent the workers’ bargaining power. Using (2)-(3) and (5)-(6), the standard necessary first-order condition for the generalized Nash bargaining problem is:

\[
 \frac{1 - \beta}{\beta(1 - b_1)} (W(j,i) - U(j,i)) = J(j,i) - V(i)
\]

Free-entry in vacancies implies

\[
 V(i) = 0
\]

The skill composition of the unemployed workers in (6), \( z_{ji} \), depends of the skill-composition of the population and the matching and hiring rates. In a steady-state, the equalization of the flows in and out of employment implies:\(^{15}\)

\[
 z_{si} = p_{si} \frac{\nu(v_i/u_i) \pi_{ns|s} + \lambda + \rho}{\nu(v_i/u_i) \pi_{si} [1 - p_{si}] + \pi_{ns|s} p_{si} + \lambda + \rho}
\]

An equilibrium consists of values of market tightness \( v_i/u_i \), wages \( w(j,i) \), hiring \( \pi_{ji} \) and skill mix \( p_{ji} \), for \( i = e, ne \) and \( j = s, ns \), and overeducation \( \phi \), such that (1)-(10) hold.

\(^{15}\)Note that, since (8) must hold, from (3) and (6) workers always accept the job offers they receive.
3 Equilibrium characterization

Although our main interest is in the interactions between the career (or overeducation) choice $\phi$ and the rest of labor market outcomes, we begin with the case in which the career decision is exogenous. By (1) the distribution of skills (i.e., the $p_{ij}$'s) is given too and the equilibrium can be studied for each segment $i$ separately. It can be characterized by the two standard relationships. The first relation comes from the bargaining condition (8). This is the job-destruction curve

$$
\eta_j - w(j,i) = \frac{(r + \rho + \lambda)(1 - \beta)(1 - b_1)\eta_j - b_0}{(1 - b_1)(r + \rho + \lambda + \beta\nu(v_i/u_i))\pi_{ji}} \tag{11}
$$

which traces out a positive relation between the wage and the equilibrium market tightness – provided that the minimal condition $\eta_j(1 - b_1) - b_0 > 0$ holds. A higher probability of meeting a vacancy for the worker, $\nu_i$, means that the outside option of a job is also higher. Hence the wage has to be also higher to retain the worker. Since $\nu_i$ depends positively of market tightness, the positive relation between $v_i/u_i$ and $w(j,i)$ follows. The second relation comes from the free-entry condition (9). It gives the job-creation curve:

$$
\xi(v_i/u_i) \sum_{j=s,n,s} z_{ji}\pi_{ji} \left[ \frac{1}{r + \lambda + \rho} (\eta_j - w(j,i)) - c_k \right] - c_R = 0 \tag{12}
$$

where

$$
\pi_{ji} = \begin{cases} 
0 & \left( \frac{1}{r + \lambda + \rho} (\eta_j - w(j,i)) - c_k \right) < 0 \\
1 & \text{otherwise}
\end{cases}
$$

and $z_{ji}$ as in (10). A higher probability of contacting a worker, $\xi_i$, increases the expected profits for the firm. Free-entry would drive the wages upwards so as to restore the zero value of creating vacancies. Since $\xi_i$ depends negatively on market tightness, a negative relation between $v_i/u_i$ and wages follows. The equilibrium in a segment $i$ can be expressed as a market tightness $v_i/u_i$ that satisfies (12) having substituted the right hand side of (11) for the firm’s net revenue.

The (so far) given educated unskilled worker’s segment decision $\phi$ enters this equilibrium condition through changes in skill mix $p_{sij}$ from (1) and thus the probabilities of firms to find skilled workers $z_{sij}$ in (12). In particular, overeducation $\phi = 1$ improves the skill composition in the educated segment and worsens it in the non-educated segment with corresponding consequences for tightness, wages and hiring in each segment.

Turning now to the endogenous choice of segment, it is determined according to (4), with the equilibrium values of searching in alternative segments satisfying

$$
(r + \rho)U(j,i) = b(w(j,i)) + \nu(v_i/u_i)\pi_{ji} \frac{w(j,i) - b(w(j,i))}{r + \rho + \lambda + \nu(v_i/u_i)\pi_{ji}}, \tag{13}
$$

which follows from (2) and (3). Then the skill mix is determined from (1).
3.1 Properties

We describe formal properties useful for understanding the implications of the model. We restrict attention to situations where equilibrium outcomes may be of practical relevance. Both segments are operative and skills are more numerous in the educated segment \( p_{s|e} > p_{s|ne} \). It is thus that the supposition maintained so far that the skilled educated workers always choose endogenously the educated segment must be met in equilibrium.\(^{16}\) That skilled educated workers choose the educated segment implies in turn a higher tightness in the educated segment \( v_{e}/u_{e} > v_{ne}/u_{ne} \) (see (4) with (13)). Regarding the hiring policies in (12), since both segments are operative, firms must be willing to hire at least the skilled workers, so we will have \( \pi_{s|e} = \pi_{s|ne} = 1 \). Finally, in order for some non-skilled workers to find employment, only situations where \( \pi_{ns|ne} = 1 \) will be considered.

We can now turn to the more interesting choices affecting overeducation. The decision whether an educated firm hires an unskilled worker \( \pi_{ns|e} \) should obviously be crucial for the educated unskilled worker’s segment choice \( \phi \). An unsurprising yet important result (details in the Appendix 1) is that educated unskilled workers will turn to the non-educated segment and become overeducated \( \phi = 1 \) when and only when they see no chance of employment in the educated segment as \( \pi_{ns|e} = 0 \). Note that, since it has to be assumed that \( (1 - b_1)\eta_{ns} - b_0 > 0 \) for the non-educated firms to hire non-skilled workers, overeducation can only happen if the cost of creating a job \( c_k \) is positive. This is clear from inspection of (12) and (11). In general, one has to account for the possibility that, for some values of the parameters, two equilibria exist, one with overeducation \( \phi = 1 \) and another without it \( \phi = 0 \).

In order to make this characterization more precise we introduce Figure 1. It represents the left-hand side of (12) for the educated segment \( i = e \), having used (11) to replace the terms \( \eta_j - w(j,e) \), and on account of (10) and (1) to describe the terms \( z_{s|e} \). It is a piecewise decreasing function of the segment’s tightness \( v_{e}/u_{e} \). It has a discontinuity at the value \( (v_{e}/u_{e})^* \) where \( \pi_{ns|e} \) shifts from 1 to 0 or, in other words, the value where it is no longer profitable for firms in segment \( e \) to hire non-skilled workers, and where non-skilled workers will therefore switch and turn to the non-educated segment for employment. At this point, the probability of meeting a skilled worker among the pool of unemployed in the educated segment, \( z_{s|e} \) in (10) with (1), jumps because all the non-skilled workers have withdrawn from this segment. Two equilibria may then exist due to this discontinuity.\(^{17}\) A zero to the right of \( (v_{e}/u_{e})^* \) is a situation where non-skilled workers are not hired; to the left of \( (v_{e}/u_{e})^* \) both skill types are hired. The specific case depicted in Figure 1 is one of a unique equilibrium of the latter type, without overeducation.

\(^{16}\)Skilled educated workers must decide to participate in the educated segment. Otherwise non-skilled workers would be the only participants in it, which would be inconsistent with the restriction on \( p_{j|i} \)’s.

\(^{17}\)Specifically, \( z_{s|e} = \mu(s,e) / (\mu(s,e) + \mu(ns,e)) \) when \( \pi_{ns|e} = 1 \), and \( z_{s|e} = 1 \) otherwise. Instead, for the non-educated segment, the analogous mapping has no discontinuity as both skills are hired there.
3.2 Comparative statics to a SBTC

Suppose the economy is initially at a unique steady state without overeducation, or \( \Phi = 0 \), so the equilibrium market tightness in the educated segment is determined as in Figure 1. We have assumed that the majority of educated individuals are skilled and that the majority of non-educated workers are non-skilled. In the initial economy this means, by (1), that the skills composition of the labor force in each segment satisfies that \( p_{s|e} > 0.5 \) and \( p_{s|ne} < 0.5 \).

We can now describe the consequences for overeducation of a SBTC. Following Mortensen and Pissarides (1999) we will represent SBTC as a mean-preserving increase in the productivity gap between skilled and unskilled workers.\(^\text{18}\) This is reasonable as description of a process where non-skilled productivity lags behind the rest of the economy, with aggregate productivity and hence the other relevant aggregate variables - including \( b_0 \), \( c_k \) and \( c_R \) - growing faster. It is also consistent with the measurement of the technological skill bias in empirical work using an aggregate production function.\(^\text{19}\)

\(^\text{18}\)In their steady-state model, like in ours, equilibrium unemployment is neutral with respect to the common trend in market productivity, hence, after de-trending, a permanent skill-biased shock to technology can be interpreted as a mean-preserving spread change. Cuadras-Morató and Mateos-Planas (2006) perform the same type of exercise. In Acemoglu (1999) the cost of vacancies is endogenous and increases when, in the course of SBTC, the productivity of skilled workers increases, thus also rendering non-skilled workers less productive relative to aggregate variables. This is also true in Moore and Ranjan (2005) where a SBTC brings about shifts in sectoral demands.

\(^\text{19}\)For instance, Katz and Murphy (1992) or, more recently, Autor, Katz, and Kearney (2008), as well
Therefore two separate channels of effects on overeducation are at work following a SBTC. Consider first the increase in skilled productivity $\eta_s$, while holding all the other parameters (including non-skilled productivity) unchanged.\textsuperscript{20} This technology change can effect a switch from the initial hiring policy of firms in the educated segment. Under the given conditions, this aspect of a SBTC increases the value of vacancy creation in the educated segment as represented by the left-hand side of (12) with (11), (10), and (1). Therefore, market tightness $v_e/u_e$ increases as the curve in Figure 1 shifts upwards. Rising tightness undermines the employers’ negotiation position and erodes the profitability of hiring unskilled workers $\eta_{ns} - w(ns,e)$, and can render them unprofitable and unemployable in this educated segment (see the denominator in (11)). Graphically, the equilibrium may come to lie to the right of the discontinuity point.\textsuperscript{21} Educated yet unskilled workers turn to the non-educated segment and overeducation arises. This shows that the rise in skilled productivity alone is already sufficient to cause overeducation.

There is a second channel which comes into play since a SBTC is associated also with a relative reduction in non-skilled productivity $\eta_{ns}$. In our model, this change also decreases the educated-segment firm’s profit margin to using a non-skilled worker, $\eta_{ns} - w(ns,e)$. The reduction in relative productivity of the non-skilled workers $\eta_{ns}$ (see the numerator in (11)) adds to the already-seen rising tightness in the educated segment (i.e., the denominator in (11)) as a force leading to the emergence of overeducation.

In the labor market, overeducation will reinforce the widening gap between skilled and non-skilled wages within the two segments, the rise in tightness in the educated segment and its fall in the non-educated segment. As for aggregate measures, the emergence of overeducation gives rise to a fraction of the educated labor force whose wages and unemployment will come to be determined within the high-unemployment and low-wage segment of non-educated jobs. We will now explore the significance of these mechanisms in a calibrated example of the model.

4 A numerical exercise

This section illustrates the mechanisms discussed above by means of a numerical example. We demonstrate how a SBTC can cause a switch towards a regime with overeducation and, on the other hand, how overeducation in turn affects wages and unemployment. As Krusell, Ohanian, Rios-Rull, and Violante (2000) study the role of technology for the wage structure focusing on changes in the quality of labor inputs relative to skill-neutral changes. Thus, abstracting from changes in absolute output arising from factor-neutral technological change and from changes in the scale of the economy, non-skilled productivity falls and skilled productivity rises relative to aggregate output and, hence, relative to other aggregate variables. See, for example, Greenwood and Yorukoglu (1997) for a macroeconomic analysis containing this feature.

\textsuperscript{20}This is the version of SBTC in Albrecht and Vroman (2002) and Shi (2002).

\textsuperscript{21}First, as one of two possible equilibria, but eventually as a unique one.
though the model is conveniently parsimonious, we can still choose parameters that deliver observationally reasonable outcomes.

As justified in the previous section, we represent SBTC as a mean-preserving increase in the productivity spread. As it turns out, it accounts for a substantive part of the observed variation in wages and unemployment. Not being a central object of this analysis, this is nonetheless a welcome feature which enhances the quantitative relevance of the analysis of overeducation. However we will also demonstrate the established result that the rise in skilled productivity alone can indeed account for a rise in overeducation.

4.1 Calibration

One model’s period is assumed to correspond to one quarter. Table 1 displays and describes the calibrated parameters and the U.S. 1970 targets. Most choices and targets are common in the literature. The distribution of education and skills is more specific. It is chosen to match targets of educational attainment and measures of inequality within defined occupational categories. The target for education is the 1970 figure for college participation of the male labor force aged 25 from the US Census Bureau. Concerning inequality within job categories, the target is the differential of log-wage residual variance between educated and non-educated jobs in 1970 from Gould (2002). The start-up cost $c_k$ is chosen small enough so that in 1970 there is a regime of low (zero) overeducation or $\phi = 0$ on account of the evidence discussed earlier that 1970 precedes the rise in overeducation.

Table 1: Calibration

<table>
<thead>
<tr>
<th>description</th>
<th>parameter</th>
<th>value</th>
<th>target to match</th>
</tr>
</thead>
<tbody>
<tr>
<td>unemp. benefit rate</td>
<td>$b_1$</td>
<td>0.2</td>
<td>UI replacement 20%</td>
</tr>
<tr>
<td>quarterly interest rate</td>
<td>$r_1$</td>
<td>0.013</td>
<td>annual interest 5%</td>
</tr>
<tr>
<td>death rate</td>
<td>$\rho$</td>
<td>0.0055</td>
<td>working life 45 years</td>
</tr>
<tr>
<td>separation rate</td>
<td>$\lambda$</td>
<td>0.06</td>
<td>annual separation rate 25%</td>
</tr>
<tr>
<td>matching</td>
<td>$\theta$</td>
<td>0.5</td>
<td>matching elast. 0.5</td>
</tr>
<tr>
<td>start-up cost</td>
<td>$c_k$</td>
<td>0.05</td>
<td>zero overeduc. $\phi = 0$</td>
</tr>
<tr>
<td>distribution educ &amp; skills</td>
<td>$\mu(ns,e)$</td>
<td>0.085</td>
<td>share with college 25%</td>
</tr>
<tr>
<td></td>
<td>$\mu(s,e)$</td>
<td>0.165</td>
<td>residual-variance gap 0.06</td>
</tr>
<tr>
<td></td>
<td>$\mu(s,ne)$</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\mu(ns,ne)$</td>
<td>0.715</td>
<td>mass of 1</td>
</tr>
<tr>
<td>skilled productivity</td>
<td>$\eta_s = 3 - \eta_{ns}$</td>
<td>1.915</td>
<td>wage premium 1.44</td>
</tr>
<tr>
<td>fixed unemp. benefit</td>
<td>$b_0$</td>
<td>0.770</td>
<td>unempl. educated 1.1%</td>
</tr>
<tr>
<td>worker bargaining</td>
<td>$\beta$</td>
<td>0.140</td>
<td>unemp. non-educated 2.4%</td>
</tr>
<tr>
<td>recruiting cost</td>
<td>$c_R$</td>
<td>0.100</td>
<td>percentage of wage 2%</td>
</tr>
</tbody>
</table>

\(^{22}\)This calibration follows Cuadras-Morató and Mateos-Planas (2006) closely. Further details and data sources can be found there.
4.2 Results

The skill-biased shock is represented by a rise in the productivity of the skilled workers, \( \eta_s \), with a corresponding decline in the productivity of the non-skilled workers that leaves \( \eta_s + \eta_{ns} \) unchanged.\(^{23}\) The results of the experiments conducted are contained in Table 2. Each row shows the value of the parameters \( \eta_s \) and \( \eta_{ns} \), and the equilibrium choice \( \phi \) which characterizes the presence (if 1) or absence (if 0) of overeducation. The rest of entries in each row contain the key observable variables: wage premium \( wp \), unemployment rate of the educated and non-educated \( un_e \) and \( un_{ne} \), and residual inequality for each group \( res_e \) and \( res_{ne} \). Line 1 shows the figures corresponding to the benchmark 1970 equilibrium. Line 2 reproduces, to facilitate comparison, figures observed in 1990.

The remaining lines show the changes in the variables as \( \eta_s \) is increased. Line 3 corresponds to an equilibrium where, like in the initial benchmark, there is no overeducation. The wage premium, the measures of residual inequality, and the unemployment rate for the non-educated have increased. However, the unemployment rate of the educated labor force fails to increase (it even declines slightly). Now for the same parameters, this economy has another equilibrium with overeducation shown in line 4. The first important point is that a SBTC can bring about overeducation. The second point of note is the increase in the educated unemployment rate which follows solely from the rise in overeducation. Besides, we also see that overeducation helps account for the increase in the other variables (except for residual inequality of the non educated).

Lines 5 and 6 display outcomes associated with further SBTC. The equilibrium here is unique and features overeducation in that \( \phi = 1 \). These cases show that a further SBTC continues to raise the educated unemployment rate when there is a (even constant) degree of overeducation. With positive overeducation, some educated are exposed to the worsening conditions in the non educated segment. In the bottom line we nearly match the observed 1990 wage premium and can produce nearly all of the observed rise in educated unemployment rate and about sixty per cent of the rise in the non-educated unemployment, as well as a sizeable upward shifts in residual inequality.

In the numerical experiments reported above, when a SBTC occurs, non-skilled workers fall behind the aggregate economy. As discussed in the previous section, however, the increase in skilled productivity alone is enough to cause overeducation, even when non-skilled workers’ is left unchanged. We demonstrate this property here by increasing the productivity of skilled workers \( \eta_s \) but holding non-skilled productivity constant. For an increase in \( \eta_s \) to 4.70 there is equilibrium multiplicity including overeducation; for a higher \( \eta_s \) of 6.50, the equilibrium with overeducation is unique.\(^{24}\)

\(^{23}\)Other specifications leave the results largely unaffected. This is the case, for example, when the changes in productivity are weighted by demographic size.

\(^{24}\)The quantitative implications for inequality and unemployment are obviously less satisfactory. The significance of overeducation for those variables is preserved though.
Table 2: Responses to skill biased technical change

<table>
<thead>
<tr>
<th></th>
<th>skill bias</th>
<th>overeducation</th>
<th>observable variables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\eta_s$</td>
<td>$\eta_{ns}$</td>
<td>$\phi$</td>
</tr>
<tr>
<td>(1) 1970 benchmark</td>
<td>1.915</td>
<td>1.085</td>
<td>0</td>
</tr>
<tr>
<td>(2) 1990 observed</td>
<td>1.980</td>
<td>1.020</td>
<td>0</td>
</tr>
<tr>
<td>(3) 1.990</td>
<td>1.533</td>
<td>0.011</td>
<td>0.032</td>
</tr>
<tr>
<td>(4) 1.990</td>
<td>1.561</td>
<td>0.018</td>
<td>0.035</td>
</tr>
<tr>
<td>(5) 2.010</td>
<td>1.594</td>
<td>0.020</td>
<td>0.041</td>
</tr>
</tbody>
</table>

4.3 Alternative potential explanations

In the U.S., the period considered has also witnessed a rapid surge in the share of college educated workers in the labor force. Could this provide an explanation, alternative to the SBTC, for the rise in overeducation? If the increase in college participation does not change the skill composition of the educated labor force, $\mu(s,e)/\mu(ns,e)$, then the model predicts no effect on the results. The reason is that within each segment it is the skill composition of searching workers, but not their mass, that matters for wages and tightness. Hiring policies in the educated segment remain unchanged and thus overeducation will fail to arise.

Another possibility is that the sharp rise in graduated numbers may have undermined the average quality of educated workers, perhaps because of the entry of less talented individuals. In the model, this change amounts to a reduction in the skill share within the educated group $\mu(s,e)/\mu(ns,e)$ which reduces the value of vacancy creation in the educated segment and causes market tightness to decline in this segment, educated unemployment to increase, and the wage premium to decline. Workers become less demanding in negotiations and firms will then be less likely to turn down the least skilled individuals. So overeducation will also fail to materialize in this case.

There remains the important question whether making education endogenous in this model would imply the observed surge in the share of educated workers. It might first appear contradictory with the contemporaneous increase in overeducation. Unskilled workers who take on education only in order to gain access to educated jobs will lose the incentive to do so if there is overeducation. A SBTC would lead to a reduction in college attendance and, since no unskilled worker would take education, overeducation will decrease to effectively vanish. However, this problematic implication might be overcome if educa-

25However, once the equilibrium has switched to the overeducation regime – perhaps because of SBTC – this change in the quality of educated workers would further increase, as a direct composition effect, the proportion of overeducated individuals. Evaluating its actual contribution to observed changes in overeducation would require the quantitative analysis of a more elaborated model, possibly involving a richer distribution of skill levels.

26We thank the Editor Arpad Abraham for his suggestions on this.
tion produces skills. In a similar model with endogenous education, Cuadras-Morató and Mateos-Planas (2006) show that SBTC causes a rise in educational attainment by raising the wage premium and the relative employment chances for the educated workers. In that model, education increases the probability that the worker will become skilled. There the increase in overeducation that occurs in the present setting might mitigate the incentive to increase participating in education but should not overturn it. Since the outcome of schooling is random, even workers that become ex-post overeducated will have found it ex-ante optimal to get educated after a SBTC.

5 Concluding remarks

This paper has considered an extension of the standard search-matching model of the labor market by introducing segmentation (or directed search), an imperfect correlation between education and productive ability, and positive job start-up costs. In this context, a SBTC, extensively analyzed as a main cause of wage inequality, can also be responsible for the rise in overeducation observed in the data. This type of causal connection has been suggested in the recent empirical literature on job polarization. In contrast, in existing models a counterfactual fall in overeducation would follow. Furthermore, in our model the endogenous response of overeducation helps account for the generalized higher unemployment rates and wider wage inequality observed in the U.S. over 1970-1990, allegedly a period of rapid SBTC.

Key to the model’s plausible implications is its depiction of overeducation as involving workers who, in spite of holding a formal qualification, have inadequate skills. As indicated, there is some direct empirical support for this view. Other papers in the literature have however taken the different view that educated workers are all highly apt and overeducation then reflects their decision to accept unqualified job offers and be mismatched. It is likely that both forms of overeducation are present in practice. In further research, the rigorous analysis of a suitably quantitative model will attempt to identify both types of overeducation and establish their actual relevance for labor market outcomes.
References


Appendix 1 - Hiring and career choice.

Consider an equilibrium. Then $\pi_{ns|e} = 0$ if and only if $\phi = 1$. The argument is as follows.

If $\pi_{j|i} = 1$ then (6) and (8) imply that $W(j, i) - U(j, i) > 0$. Using this in (2) and (3) shows that if $\pi_{j|i} = 1$ then

$$(r + \rho)U(j, i) = b(w(j, i)) + \frac{\nu_i \pi_{j|i}}{\nu_i \pi_{j|i} + \lambda + r + \rho} (w(j, i) - b(w(j, i))),$$

with $w(j, i) - b(w(j, i)) > 0$. On the other hand, if $\pi_{j|i} = 0$ then, by (3), $(r + \rho)U(j, i) = b(w(j, i))$.

First one has to prove that $\pi_{ns|ne} = 1$ and $\pi_{ns|e} = 0$ imply $\phi = 1$. The result requires, from (4), $U(ns, e) < U(ns, ne)$. Given the preceding discussion, it suffices to prove that $w(ns, ne) > w(ns, e)$, which follows by using (11).

Second one has to prove the reverse that $\pi_{ns|ne} = 1$ and $\phi = 1$ imply $\pi_{ns|e} = 0$. One can proceed by contradiction by assuming $\pi_{ns|e} = 1$. Use the discussion opening this proof to write the expressions for $U(ns, e)$ and $U(ns, ne)$. Using that $\nu_e > \nu_{ne}$ and, from (11), that $w(ns, e) > w(ne, ne)$, it follows that $U(ns, e) > U(ns, ne)$. From (4) this is a contradiction with the assumption that $\phi = 1$. 